Understanding CMS Endcap Hadron Calorimeter

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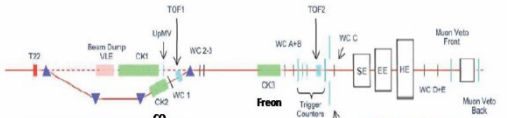
The experimental setup of Test Beam

- A slice of the CMS calorimter was tested during summer of 2007 at the H2 testbeam area at CERN with different beam energies ranging from 1 GeV to 300 GeV.
- The endcap calorimeters, namely the Hadron Endcap (HE), Eelectromagnetic Endcap (EE) and Endcap Preshower (ES) were tested. ES was introduced for the first time in testbeam 2007.
- Data is taken for these protypes where every individual layers were readout separately.
- The HE is divided in a tower structure (eta, phi).
- The EE is readout crystal by crystal.
- The ES is readout as micromodules. The figure shows the structure of ES.

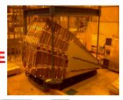
The beam line of TB2007 with Particle Identification

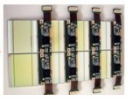


Beam:
Pions, electrons, muons, protons
2-350 GeV/c momentum range

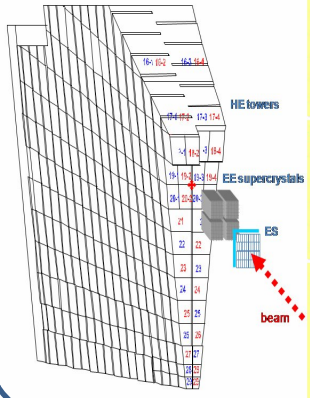
Beam cleaning:
Trigger counters – single particle
Beam Halo scintillators – interaction in beam line

Particle indentification:
Muon veto scintillators
Cerenkov detectors (CK1, CK2, CK3)
Time of flight system (TOF1, TOF2)





A slice of the HE+EE+ES 2007 test beam setup showing the towers

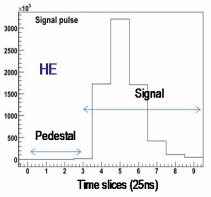


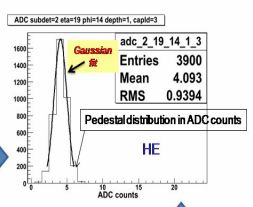
ES:
- Two X and Y layers
- each with 2 Ladders (2x4)
- total 32 Si-detectors
- real electronics 1024 channels
- separated DAQ, DCS, DQM

EE:
- Four SuperCrystals
- each with 5x5 crystals
- total 100 crystals
- real electronics
- separated DAQ, DCS, DQM

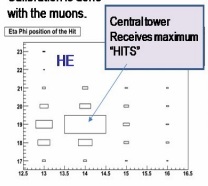
HE :
- Depth segmentation:
  - Eta = 16 (1 depth segment)
  - Eta = 17-23 (2 depth segments)
  - Eta = 24-25 (3 depth segments)
  - Eta = 26-29 (no tile)
- Phi segmentation:
  - Δφ = 5 degrees for Eta = 21

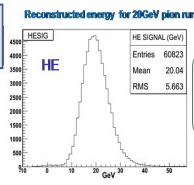
How energy is measured in the calorimeter





Calibration is done with the muons.

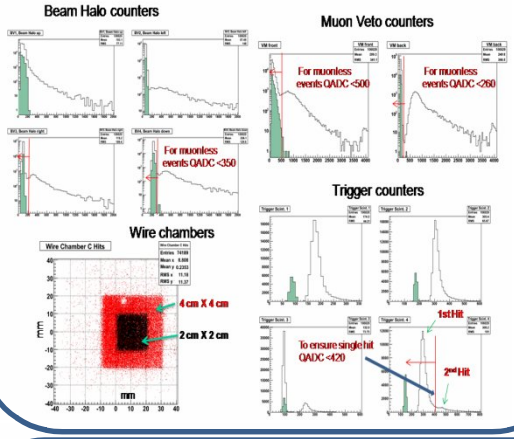




Subtract the pedestal from the signal

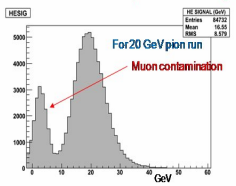
Pedestal subtracted signal multiplied with conversion factors to bring the unit in GeV

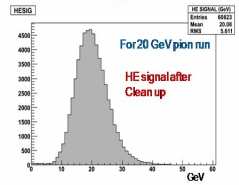
Beam cleaning – removing muon contamination



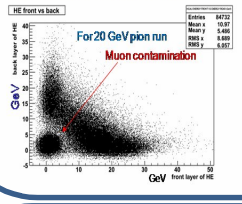
Effect of beam cleaning on the signal in hadron endcap calorimeter

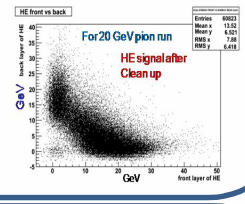
(Reconstructed energies in the 4X4 towers summed up)



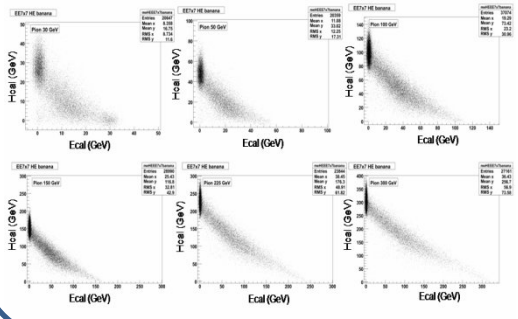


- HE has two depths. Energy deposited (GeV) in the front and back of the endcap hadron calorimeter look like the plots below:





Ecal vs Hcal energy distribution at different beam energies



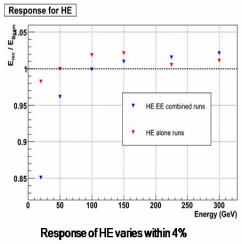
Response and Resolution for Hadron Endcap

Response of a detector is defined as the ratio of energy deposited to the nominal beam energy.

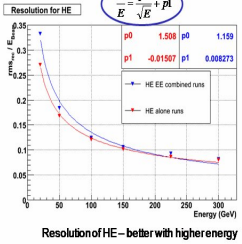
Resolution of a detector comes from statistical uncertainty, noise of the detector and fluctuations.

$$\left(\frac{\sigma_E}{E}\right)^2 = \left(\frac{A}{\sqrt{E}}\right)^2 + \left(\frac{B}{E}\right)^2 + C^2$$

A = due to sampling fluctuations which are Poisson in nature
B=contribution due to electronics (e.g. ADC resolution)
C=contribution due to calibration errors and other systematic effects



Response of HE varies within 4%



Resolution of HE – better with higher energy

Conclusions:

- Data from test beam 2007 for HCal standalone setup and for HCal with ECal in front are analysed.
- Beam clean up was done at a preliminary level.
- Response seems to be lesser for low energies for the combined set up. This is because in the combined setup showering starts earlier having material of the ECal in front.
- Resolution improves with increasing energy. At lower energies resolution for HCal standalone is better than that for the combined setup.